

*Office of Technical Assistance Research Proposal*  
***Alternatives for Cleaners (and Potentially for Coating Carrier Medium)***  
***in Coated and Laminated Substrate Manufacturing***

**BACKGROUND:**

Coated and laminated substrate manufacturing encompasses several industrial sectors, facilities with different profiles, and a variety of coating chemistries/processes. Organic solvents are often used as a carrier medium in formulating of the raw coating materials and equipment cleaning. Current cleaning chemicals include toluene, methyl ethyl ketone (MEK), 1,1,1-trichloroethane, mineral spirits, and xylene. Less frequently, perchloroethylene and heptane are used in adhesive cleaning, and isopropyl alcohol is used in press cleaning. Toluene is the most common cleaning solvent followed by MEK and 1,1,1-trichloroethane.

There are two major categories in the coated and laminated substrate manufacturing: large dedicated line facilities, and small batch-processing facilities. In general, large facilities, which operate dedicated lines, formulate all of their own coatings from raw materials. Smaller coating and laminating facilities tend to purchase premixed coatings which they use either as-shipped or modify to satisfy customer needs. According to an EPA report<sup>1</sup>, equipment cleaning accounts for approximately 1 percent (10,000 lb.) of the toluene releases from typical large dedicated line facilities; approximately 3 percent (500 lb.) for typical small, dedicated line facilities; and approximately 75 percent (110,000 lb.) for typical small, batch facilities. Nationally, there are more small batch and small dedicated line facilities than other types of facilities. Table (A) lists the aggregate chemical usage by Massachusetts companies for a selected number of SIC codes relevant to coated and laminated substrate manufacturing.

Batch processors are likely to use toluene and MEK because a high level of cleaning is required due to product changeover. Alternative cleaners such as mineral spirits, which may be adequate for dedicated line facilities for some cleaning applications, are often described by batch processors as inadequate.

Equipment involved in raw material mixing (e.g., vessels, speed dispersers, piping), web transport apparatus (e.g., rollers, gearboxes, belts, equipment housings), and mechanisms used to supply, meter, and apply coating are all subject to contamination. Consequently in general, parts of different size, configuration, and material need to be cleaned. Different cleaning methods (such as dipping, wiping, and spraying) may be used in the cleaning operations. Some equipment must be cleaned in place. Additionally, some facilities pack their coating transport lines with solvent during production shutdown periods to avoid the curing of coatings in the line. In general, the cleaning wastes and emissions comprise of spent solvent, contaminated rags/solid materials, contaminated water (in certain cases), and air emissions.

The solvents required to clean the equipment are essentially determined by the resin in the coating formulation. Typically, facilities using solvent-based coatings use the primary carrier-solvent in the coating formulation for the cleaning. If the formulation solvent is not used for cleaning, another solvent with strong cleaning power is used. Water-based coatings may be

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<sup>1</sup> EPA Research and Development Report, Improved Equipment Cleaning In Coated And Laminated Substrate Manufacturing Facilities (Phase II), July 1995

cleaned with water (with possible IPA addition) prior to drying. Other dried, non-solvent based coatings require the same cleaning procedure as the solvent-based coatings.

### **PROBLEM OUTLINE:**

Many of organic solvents used in web processing and cleaning operations are Hazardous Air Pollutants and/or Volatile Organic Compounds (as defined by the EPA), and their emission into the environment causes problems. A need exists for identification of environmentally friendly and cost-effective chemistries in cleaning operations and formulation of coatings.

The current available alternative methods of coating/cleaning that lead to substantial reduction/elimination of solvent usage are not completely applicable across the entire industry for web coating. Currently, 100-percent-solids, UV, and water-based formulations are available for certain types of coatings and applications. However, these chemistries/technologies do not work in all circumstances. For example, retrofitting equipment designed for solvent-based coatings to accommodate water-based formulations can be a complicated and costly task.<sup>2</sup>

It is reasonable to expect that the application of a new technology would be limited if its implementation in each coating/process type would require development work. This issue especially affects batch processors. An example of this situation is the supercritical carbon dioxide technology in spray coating operations. Supercritical carbon dioxide has been used as a carrier in place of low and medium molecular weight solvents in coating formulations in some applications (automotive and furniture coating). It is believed that the technology can be implemented for a variety of coating types used in spray coating.<sup>3</sup> However, development work is required to implement the technology for new coatings. The major limiting factors in implementation of this technology are (a) the high capital cost for small facilities, and (b) lack of consistency in the coating formulation specifications in a job shop.

Newly developed environmentally friendlier substitutes, such as soybean derivatives (methyl soyate, methyl ester soyate) in proprietary formulations, have been used to replace solvents such as methylene chloride, TCA, and MEK in certain applications (e.g., metal cleaning, and paint removal). No evaluation has been made regarding their applicability in web-processes. Other substitutes such as propylene carbonate, dibasic ester, non-VOC solvents (e.g., acetone), and high-pressure hot-water sprays have been suggested for web equipment cleaning in the literature. Aqueous and semi-aqueous cleaners have been used, but these also have certain limitations and environmental concerns. A combination of mechanical and solvent cleaning has been used in some cleaning operations to reduce solvent usage. No study on a systematic evaluation of the effectiveness of these alternatives in various applications has been located.

### **RESEARCH OBJECTIVES AND SCOPE:**

- a)** Identify/develop environmentally friendly cleaning chemistries for replacing the currently used solvents in web-coating operations.
- b)** Evaluate the extent of applicability of the substitute(s) in various types of web-coating applications. (Evaluation should include different facility types, different

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<sup>2</sup> EPA Research and Development Report, Solvent-Based to Waterbased Adhesive-Coated Substrate Retrofit, volume I: Comparative Analysis, April 1996.

<sup>3</sup> Application of supercritical fluid expansion in web-coating may be feasible.

coating/contaminants, different cleaning methods, different part/equipment configurations, etc.) Compare the cleaning effectiveness of the new alternative(s) with the currently used cleaning agents.

- c) Perform a life-cycle analysis of the cleaning agent. (An assessment of waste generation issues and cost-effective means of reuse/recycling of the waste should be included in this analysis).
- d) Partnership with industry: Test the alternative cleaning (and coating if reformulation of the coating is involved) chemistry in large-scale applications. OTA can assist in the identification of such companies.

<b>Chemical</b>	<b>Usage lb.</b>	<b>By Product lb.</b>	<b>Emissions, lb. (Form R, Item 8)</b>	<b>No. of Facilities lb.</b>
Toluene	37,918,838	14,327,973	5,540,617	75
MEK	19,031,609	8,615,824	2,441,143	56
TCA	121,497	86,268	87,273	4
Xylene	5,442,846	1,077,137	533,896	44
Perchloroethyl ene	362,175	101,847	101,955	10
Heptane	Below Threshold	-	-	-
Mineral Spirits	Below Threshold	-	-	-
<b>TOTAL</b>	<b>62,876,965</b>	<b>24,209,049</b>	<b>8,704,884</b>	<b>189</b>

Table A: Massachusetts Use of Cleaning Chemicals in Selected Coated and Laminated Substrate Manufacturing Facilities (SIC codes: 2295, 2385, 2387, 2389, 2393, 2399, 2652, 2655, 2656, 2671, 2672, 2673) (Compiled from 1998 TRI and TURA Data)